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# ORIENTATION-ERROR ACCIDENTS IN REGULAR ARMY AIRCRAFT DURING FISCAL YEAR 1967: RELATIVE INCIDENCE AND COST

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## SUMMARY PAGE

### THE PROBLEM

From the military mission viewpoint, the amount of research effort to be expended on the solution of a given aviation medicine problem must be keyed to the operational cost of the problem. Therefore, a necessary first step in the development of a solution is the assimilation of data that define the magnitude of the problem. Though orientation-error accidents involving pilot disorientation and vertigo have been long recognized to exist, little quantitative data are available to describe the actual incidence and cost of such accidents in Army aviation.

### FINDINGS

To initiate the action necessary to establish the magnitude of the orientation-error problem in Army aviation, an interservice research program was organized under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory, the U. S. Army Board for Aviation Accident Research, and the Naval Aerospace Medical Research Laboratory. The first step was the construction of an operational definition of an orientation-error accident. The assimilation of data pertaining to the incidence and cause of such accidents and their actual and relative costs in terms of fatalities, injuries, and aircraft damage was then set as the working objective of the program. Accordingly, the decision was made to implement a five-year longitudinal study of all major and minor orientation-error accidents involving Regular Army flight operations beginning with fiscal year 1967. Findings will be summarized on a fiscal-year basis in three separate lines of reports: The first line will be devoted to defining the over-all magnitude of the orientation-error problem in all aircraft types; the second line to the presentation of similar incidence and cost data for accidents involving only the UH-1 aircraft, the predominant rotary wing aircraft in the Army inventory; and the third line to the description of the various causal factors found to be present in the major UH-1 orientation-error accidents.

This specific report is the first in the series dealing with the over-all magnitude of the orientation-error problem in all aircraft types. Incidence and cost data are presented for all Regular Army major and minor orientation-error accidents detected in the search of the fiscal-year-1967 accident files. Separate and totalized statistical data are provided for fixed wing and rotary wing aircraft as well as for accidents occurring in Viet Nam and those occurring elsewhere.

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## LIST OF TABLES



## LIST OF FIGURES

# INTRODUCTION

Orientation-error accidents arising from a pilot's erroneous perception of the true spatial motion or true spatial attitude of his aircraft have been long recognized as a significant aviation safety problem. In the flight environment man finds little difficulty in correctly perceiving his spatial orientation when clearly defined geographical landmarks are available without illusory artifact. When these visual references are not present, as is often the case during bad weather or night flight missions, man's vestibular mechanisms and other related nonvisual sensory processes become the predominant source of internally derived spatial orientation information. Though these systems function well in the normal terrestrial environment, this is not the case in the flight situation. Here man can be exposed to simple and complex combinations of forces and torques that elicit sensations of movement and perceptions of orientation which may be in complete conflict with the actual motion or attitude of the aircraft. Even with clear visibility, the same form of erroneous sensations and perceptions can result if the pattern of the external environment is conducive to the elicitation of visual illusions. For example, pilot errors can arise in the perception of aircraft motion during hovering flight over fast moving water or within wind-driven smoke or dust clouds; in the perception of aircraft attitude when sloped terrain is interpreted as being level, or a tilted cloud border or slanted tree line is perceived as representing the horizon; or in the perception of altitude during flight over water or similar planar terrain without clearly defined landmarks.

When such errors in spatial perception occur, the result may merely be a mild confusion of the pilot as to some motion, attitude, or altitude parameter. If the error is quickly recognized, the pilot can take action to establish his true perspective in space by using some other orientation reference whether it be a specific instrument or a different set of exterior landmarks. At the other extreme, the pilot may suffer intense vertigo that seriously degrades his control ability. Equally dangerous is the situation where the pilot unknowingly experiences disorientation and controls his aircraft in accordance with his erroneous concept of its true motion. In all cases, there exists the potential for an orientation-error type accident, with the level of probability of occurrence keyed to such factors as the type of aircraft being flown, the type of mission being undertaken, and the phase of flight where the disorientation event is manifested.

Though such disorientation experiences have received considerable research attention from both the aviation safety and aviation medicine personnel in the past, the advent of more demanding cost-effectiveness programs will greatly influence the extent of the support to be given to such research projects in the future. In broad terms, the research manhours and dollars to be expended on a given operational problem will be scaled in accordance with the actual magnitude or cost of the problem. For the case of pilot disorientation research in military aviation, the extent of support to be made available will be keyed to the exact magnitude of the orientation-error accident problem. In effect, research support will, directly or indirectly, be based on the over-all cost of orientation-error accidents in terms of personnel, aircraft damage, and degraded mission performance. Unfortunately, though spatial orientation difficulties are known to contribute to Army aircraft accidents (1-4), few quantitative data are available to adequately describe the

actual magnitude of the orientation-error accident problem either in terms of the incidence and cost of such accidents in relationship to themselves or in their proportionate relationship to the over-all accident problem.

With the objective of gaining such data for orientation-error accidents occurring in Army aviation, the author organized an interservice research program under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory (USAARL), U. S. Army Board for Aviation Accident Research (USABAAR), and the Naval Aerospace Medical Research Laboratory (NAMRL). The basic plan of the program was to conduct a five-year longitudinal study of the USABAAR accident records so as to identify all major and minor orientation-error accidents that occurred in Regular Army flight operations beginning with fiscal year 1967. Once identified, the desired cost data could then be extracted from the master file associated with each orientation-error accident. In addition, the plan called for an in-depth review of selected helicopter orientation-error accidents to obtain baseline data describing the various pilot/aircraft/environment/mission factors present in such accidents.

The results of the longitudinal study will be summarized in three separate lines of reports, with one report in each line prepared for each fiscal year of the study. The first line will be devoted to defining the magnitude of the orientation-error accident problem in all aircraft types. The incidence and cost of all major and minor orientation-error accidents involving all aircraft types, fixed wing as well as rotary wing, that occurred in Regular Army flight operations will be reported for each fiscal year. Since the UH-1 "Huey" helicopter has been, and is, the predominant aircraft in the Army rotary wing inventory, in fact the predominant aircraft in the combined fixed wing and rotary wing inventory, the second line of reports (for example, ref. 5) will be devoted to defining the magnitude of the orientation-error accident problem in only this aircraft. The layout and format of this line of reports will be almost identical to that of the first line. The third line of reports (for example, ref. 6) will deal exclusively with the various causal factors found to be present in all of the major UH-1 orientation-error accidents. Typical data to be presented include phase of flight, time of day, type mission, pilot experience, physiological factors, psychological factors, facility factors, environmental factors, and the like.

In this report, a summary is made of the incidence and cost of all orientation-error accidents detected in the search of the fiscal year 1967 accident files. The data cover all Regular Army flight operations involving all fixed wing aircraft and all rotary wing aircraft. Separate and totalized statistical data are provided for both forms of aircraft as well as for accidents occurring in Viet Nam and those occurring elsewhere. In the body of the report particular attention is given to the development of a format which would meet two different, but tightly related, objectives. The first objective is to show, within a given fiscal year, the relative as well as actual cost of orientation-error accidents. For this reason incidence and cost data pertaining to all types of accidents are described in addition to the orientation-error accident data. Similarly, incidence and cost data for all types of pilot-error accidents also receive separate treatment. The second objective is to utilize a graphical layout along with selected accident-rate data

that will facilitate comparison of accident data collected for one fiscal year with those collected for following years. Accordingly, the format of the later incidence and cost reports will conform to that developed for this paper.

## PROCEDURE

To initiate the program it was necessary to establish a workable definition of the class of accidents to be identified as orientation-error accidents. It will be recognized by investigators actively engaged in aviation safety research that the cliché "easier said than done" is most appropriate for this task. There would be little difficulty in identifying accidents involving pilot disorientation if the latter always manifested itself in the extreme where a pilot calls out that he is experiencing severe vertigo and is having difficulty controlling his aircraft. Similarly, when visibility is poor or the visual environment conducive to illusions, the task of identifying an accident as being related to difficulty in maintaining spatial orientation is not too difficult. However, when the factors surrounding a given accident become borderline as to whether or not a pilot made an orientation error, it is of the essence that the accident classifier be given some appropriate criteria to help him make the classification decision. Although any definition of orientation error will be compromised at times by one or more unique features of a given accident, it was felt that a workable classifying system could be developed for the vast majority of the accident types to be encountered in our review.

### DEFINITION OF ORIENTATION-ERROR ACCIDENTS

First, the term orientation is considered to involve the correct determination of the dynamic position and attitude of an aircraft in three-dimensional space. The key word here is dynamic, which implies that full knowledge of the motion as well as static attitude or position of an aircraft is required to define its instantaneous spatial orientation. For a pilot to have a full comprehension of his orientation, it is essential, for example, that he be able to describe the static pitch and roll attitude of his aircraft relative to some external reference such as the Earth-vertical defined by the gravitational vector; his yaw attitude relative to some geographical heading; the linear velocity of the aircraft, with or without attendant linear acceleration, in terms of forward, left-right, and up-down motions; and the angular velocity of the aircraft, with or without attendant angular acceleration, in terms of roll, pitch, and yaw rotary motions of the aircraft. Thus, for a fully oriented fixed-wing aircraft pilot, typical information inputs would include knowledge of the forward speed of the aircraft, the vertical speed in terms of either climb or descent rates, sideward drift velocity, pitch and roll attitude, as well as bank angles, angle of attack, et cetera. In landing or rendezvous operations, recognition of the effects of these aircraft motions on absolute distance must be made to ensure that the aircraft does not undershoot or overshoot a preselected touchdown or rendezvous point.

The rotary-wing aircraft pilot requires similar information. However, during low-level hovering conditions, additional information is required in the form of linear velocity in the backward as well as forward direction. Unfortunately, the majority of the currently operational helicopters do not have instruments that provide this backward

velocity or, for that matter, sideward drift velocity, information. The usual lack of short-range radar altimeters in helicopters is another problem confronting the rotary-wing aircraft pilot during low-level operations performed with poor ground visibility.

By this definition of the word orientation, it follows that a pilot will be considered to have made an orientation error whenever his perception of the motion and attitude of his aircraft differs from the true motion and attitude; i.e., the true orientation of the aircraft. The exact magnitude of an orientation error will obviously vary over a wide range. In the case where a pilot suffers severe vertigo and completely loses all perception of either aircraft motion or aircraft attitude, the probability of a large-scale orientation error is high, as is the probability of an accident if the disorientation is prolonged or is experienced at a critical control phase within the flight. In another case, the pilot may sense or feel that the aircraft is climbing or turning when in actuality it may be flying straight and level. If during this disorientation experience the pilot accepts that his sensations define the orientation of the aircraft, then an orientation error is present. However, if he realizes that his sensations are in conflict with another input, say the aircraft instruments, and intellectually arrives at the correct judgment of the true motion and attitude, then though the pilot is experiencing disorientation, an orientation error does not result.

Initially, then, an orientation-error accident can be defined as one that occurs as a result of an incorrect control or power action taken by a pilot due to his incorrect perception of the true motion and attitude of his aircraft. Using this definition, an accident classifier can place primary emphasis on determining whether or not the accident involved an erroneous judgment of orientation on the part of the pilot. It follows that questions pertaining to the causes of the orientation error, or its manifestation to the pilot, need not be immediately answered during the initial classification.

There must, however, be several qualifications to this definition. For instance, the accident situation must be one in which the demands on pilot skill are reasonable. To illustrate, consider a helicopter pilot who has a main rotor strike as a result of landing from a hover in a nonlevel attitude, say with an excessive roll angle. This is an orientation-error accident involving incorrect perception of aircraft attitude. The causes of the orientation error could be much varied, ranging from inattention to instruments, a tilted horizon line, visual illusions produced by a nearby moving aircraft, or distraction. A simple, but essential, assumption is that the pilot did not deliberately fly his aircraft into the ground. However, if in a similar landing from a hover situation, a nearby helicopter flies over the given aircraft and produces severe rotor downwash or turbulence, and the end result is a similar rotor strike, the accident would not be classified as an orientation-error accident. It is not reasonable to expect the pilot to maintain both perception and control of aircraft orientation under these conditions. In like manner, a tail rotor strike resulting from excessive flare applied by the pilot in a landing formation to avoid striking another aircraft making an unauthorized takeoff would not be classified as an orientation-error accident. But again, if this tail rotor strike occurred during a routine uninterrupted landing, it would fall into our classification since the pilot's perception of closing rate or pitch angle was incorrect.

A further qualification involves accidents associated with navigation errors. Though knowledge of heading is pertinent to orientation, accidents involving navigation mistakes, and only navigation mistakes, are not classified as orientation-error accidents. That is, if a pilot strikes a hillside as a result of flying a course of 100 degrees instead of 200 degrees, the error is one of navigation, not orientation. In this respect, the word misorientation has received some usage to account for navigation errors. However, if in addition to being on the wrong course or heading, a pilot is having difficulty controlling his aircraft and an accident results because of this difficulty, an orientation-error accident classification would generally result.

Accidents resulting from collision with unseen objects, e.g., a wire strike, are also not included if the collision occurs during normal controlled flight. However, if a hovering pilot allows his aircraft to drift backward, without detection, and finally to impact against an unseen object, an orientation-error classification would result. That is, collisions of this sort are included only when they derive from an orientation error.

As qualified by all of the above, an orientation-error accident is thus said to occur whenever an accident results from a pilot's incorrect perception of his true motion and attitude in space. The orientation error may range from a complete loss of all knowledge of orientation to simple confusion as to only one of the many motion and attitude parameters required to be recognized by the pilot. Or, as mentioned previously, the pilot may never realize that the motion or attitude of his aircraft is gradually changing so as to be soon unfavorable to safe flight.

## ACCIDENT-FILE SEARCH PROCEDURES

With this definition of orientation-error accidents serving as a classification reference, a comprehensive search was made of the USABAAR accident files to determine all major and minor accidents (as defined in refs. 7,8) that occurred in Regular Army flight operations during fiscal year 1967. This search involved having a classifier, with previous experience in detecting disorientation/vertigo accidents, read each and every accident brief in the master files. These briefs covered all types of accidents in all types of aircraft, fixed wing and rotary wing, and included accidents occurring in Viet Nam as well as those occurring in all other locations.

For redundancy, the entire accident file was also searched by means of the coded summaries that USABAAR prepares for each accident. These summaries, in punched card form, list the essential background data of a given accident as well as the primary causal factors. The objective was to obtain the accident identification number of all accidents involving vertigo, disorientation, poor visibility, bad weather, obstructed vision, night flight difficulties, visual illusions, and the like.

Upon completion of these two searches, the authors reviewed the accident briefs independently for the purpose of establishing whether or not an orientation-error accident classification would result. In addition, the comprehensive master file on each suspect accident was obtained and reviewed. Whenever there was serious question as to the

contribution of orientation error to the accident, or where equally weighted alternative causal factors existed, then the accident was not included in the classification. The net effect of this policy is to give a conservative estimate of the magnitude of the orientation-error accident problem.

An analysis was then made of the cost of each of these accidents in terms of personnel and dollars. In addition, the statistical section of USABAAR was asked to compile equivalent incidence and cost data pertaining to 1) accidents of all forms, and 2) accidents considered to involve pilot-error factors. These data are used to establish a baseline reference for evaluation of the relative magnitude of the orientation-error accident problem.

## RESULTS AND DISCUSSION

Before the operational significance of orientation-error accidents can be placed in proper perspective, it is necessary to have at least a cursory understanding of the incidence and costs of aircraft accidents in general. To provide this background, the first section to follow is devoted to describing the over-all cost of all Regular Army aircraft accidents, regardless of type or location, that occurred during fiscal year 1967. In a second section, equivalent data in a near identical format are presented to separately identify those accidents in the first section that were classified by USABAAR as involving one or more pilot-error factors. Cost statistics pertaining to only orientation-error accidents are then presented in a third section. By using these three sets of data as independent references, it then becomes possible to establish some quantitative insight into the relative, as well as actual, cost of orientation-error accidents in Regular Army flight operations. Selected comparative relationships of this type are presented in the last section of the report.

### ALL TYPES OF AIRCRAFT ACCIDENTS

The data presented in this section describe the incidence and cost of all major and minor aircraft accidents involving all Regular Army flight operations during fiscal year 1967. Separate data groupings are provided for accidents involving only fixed wing (FW) aircraft, only rotary wing (RW) aircraft, and their combined total. In addition, for each of these three statistical groupings, the data are divided into those accidents that occurred in Viet Nam, those accidents that occurred elsewhere, and their combined total. Since the vast majority of the accidents that do not occur in Viet Nam (VN) take place within the continental limits of the United States, the abbreviation US is arbitrarily used to denote all accidents which do not occur in Viet Nam. It should be realized then that the US data grouping will include a small number of accidents which may have occurred, for example, in Europe, Africa, or elsewhere. A second point to be stressed is that the VN data pertain strictly to accidents, not losses due to enemy action.

In the interpretation of the accident statistics to follow, it becomes possible to compare FW and RW accident incidence or VN and US accident incidence only when some common measures of aircraft utilization are selected as weighting factors. To establish

such comparative references, percent aircraft inventory, total flying hours, and total aircraft landings are used as basic weighting data in this report. These data, as well as the incidence and cost statistics presented in this section, are summarized in Tables I through IV. Table I pertains to all accidents in all types of aircraft, Table II to only FW accidents, and Table III to only RW accidents. The ratio of the RW data in Table III to the FW data in Table II is summarized in Table IV.

When the aircraft inventory data listed in Tables I through III are examined, two points become obvious. First, as listed in Table I, the average number of aircraft operating out of VN during fiscal year 1967 was much less than the number of aircraft operating elsewhere. In relative terms, only 33.31 percent of the total inventory were stationed in VN as compared to 66.69 percent stationed elsewhere resulting in a VN/US inventory ratio of 0.50 to 1 for all aircraft types. The second point to be gained from Tables II and III is that RW aircraft were the predominant aircraft in the Regular Army inventory. Of the total number of aircraft, 67.86 percent were of the RW type and 32.13 percent of the FW type. For both types of aircraft, the VN/US inventory ratio was less than unity; i.e., 0.25 to 1 for FW and 0.66 to 1 for RW. Accordingly, in terms of average aircraft inventory, the majority of the aircraft operated in US and the majority of the aircraft were of the RW type.

A similar, though smaller US predominance results when total aircraft flight hours are used as a weighting factor. These data are plotted in Figure 1A for both aircraft types and for both geographical references. The visual interpretation of this graph, as well as the majority of the remaining graphs in the report, is as follows: The group of three bars drawn at the left in Figure 1A pertain to the total flying hours of all FW aircraft. Within this three-bar group, the right-hand bar, marked VN, plots the total number of FW hours flown in Viet Nam; the left-hand bar, marked US, plots the total number of hours flown elsewhere (primarily in the United States); and the central bar of this group, marked ALL, is a plot of the direct sum of the adjacent VN and US data. The interpretation of the three-bar group drawn at the right in Figure 1A follows identically except that total hours of RW aircraft are involved. Similarly, the three-bar group at the center of the figure describes the total hours of both types of aircraft with the depicted data representing the direct sum of the adjacent FW and RW data.

The data of Figure 1A and Table I thus show that Army aircraft were flown a total of 3,624,587 hours during fiscal year 1967 of which 1,680,840 hours were flown in VN and 1,943,747 hours elsewhere. This total is composed of 816,090 hours in FW aircraft (see Table II) and 2,808,497 hours in RW aircraft (see Table III). In all cases, the US hours were greater than the VN hours. It should be observed also that the total hours flown in RW aircraft considerably exceeded the FW hours, even allowing for the fact that the RW inventory was greater than the FW inventory. That is, the over-all RW/FW flying hour ratio was approximately 3.44 to 1 while the RW/FW aircraft inventory ratio was only 2.11 to 1 (see Table IV).

Weighting-factor data with total aircraft landings as reference are plotted in Figure 1B. Again, in terms of landings, the utilization of both FW and RW aircraft was greater

TABLE I

FISCAL YEAR 1967 DATA

ALL ACCIDENT TYPES — ALL AIRCRAFT

| ACCIDENT INDEX | U.S. ACCIDENTS | VIET NAM ACCIDENTS | ALL ACCIDENTS | VN to US RATIO |
|---|---|---|---|---|
| Major Accidents | 205 | 531 | 736 | 2.59 |
| Minor Accidents | 23 | 43 | 66 | 1.87 |
| Total Accidents | 228 | 574 | 802 | 2.52 |
| Aircraft Inventory - Per Cent Total | 66.69 | 33.31 | 100.00 | 0.50 |
| Total Flying Hours | 1,943,747 | 1,680,840 | 3,624,587 | 0.86 |
| Total Landings | 7,077,716 | 4,318,454 | 11,396,170 | 0.61 |
| Major Accidents per 100,000 Hours | 10.55 | 31.59 | 20.31 | 2.99 |
| Minor Accidents per 100,000 Hours | 1.18 | 2.56 | 1.82 | 2.17 |
| Total Accidents per 100,000 Hours | 11.73 | 34.15 | 22.13 | 2.91 |
| Major Accidents per 100,000 Landings | 2.90 | 12.30 | 6.46 | 4.24 |
| Minor Accidents per 100,000 Landings | 0.32 | 1.00 | 0.58 | 3.13 |
| Total Accidents per 100,000 Landings | 3.22 | 13.29 | 7.04 | 4.13 |
| Total Dollar Cost | 14,349,335 | 81,388,364 | 95,737,699 | 5.67 |
| Average Dollar Cost per Accident | 62,936 | 141,792 | 119,374 | 2.25 |
| Total Fatalities | 68 | 294 | 362 | 4.32 |
| Average Fatalities per Accident | 0.30 | 0.51 | 0.45 | 1.70 |
| Fatal Accidents - Number | 27 | 97 | 124 | 3.59 |
| Fatal Accidents - Percent | 11.84 | 16.90 | 15.46 | 1.43 |
| Average Fatalities per Fatal Accident | 2.52 | 3.03 | 2.92 | 1.20 |
| Total Injuries (Nonfatal) | 124 | 629 | 753 | 5.07 |
| Average Injuries per Accident | 0.54 | 1.10 | 0.94 | 2.04 |

TABLE II

FISCAL YEAR 1967 DATA

ALL ACCIDENT TYPES

FIXED WING AIRCRAFT ONLY

| ACCIDENT INDEX | U.S. ACCIDENTS | VIET NAM ACCIDENTS | ALL ACCIDENTS | VN to US RATIO |
|---|---|---|---|---|
| Major Accidents | 48 | 86 | 134 | 1.79 |
| Minor Accidents | 5 | 4 | 9 | 0.80 |
| Total Accidents | 53 | 90 | 143 | 1.70 |
| Aircraft Inventory - Per Cent Total | 25.75 | 6.38 | 32.13 | 0.25 |
| Total Flying Hours | 458,534 | 357,556 | 816,090 | 0.78 |
| Total Landings | 830,147 | 347,790 | 1,177,937 | 0.42 |
| Major Accidents per 100,000 Hours | 10.47 | 24.05 | 16.42 | 2.30 |
| Minor Accidents per 100,000 Hours | 1.09 | 1.12 | 1.10 | 1.03 |
| Total Accidents per 100,000 Hours | 11.56 | 25.17 | 17.52 | 2.18 |
| Major Accidents per 100,000 Landings | 5.78 | 24.73 | 11.38 | 4.28 |
| Minor Accidents per 100,000 Landings | 0.60 | 1.15 | 0.76 | 1.92 |
| Total Accidents per 100,000 Landings | 6.38 | 25.88 | 12.14 | 4.06 |
| Total Dollar Cost | 2,287,745 | 11,859,910 | 14,147,655 | 5.18 |
| Average Dollar Cost per Accident | 43,165 | 131,777 | 98,935 | 3.05 |
| Total Fatalities | 13 | 34 | 47 | 2.62 |
| Average Fatalities per Accident | 0.25 | 0.38 | 0.33 | 1.52 |
| Fatal Accidents - Number | 6 | 14 | 20 | 2.33 |
| Fatal Accidents - Percent | 11.32 | 15.56 | 13.99 | 1.37 |
| Average Fatalities per Fatal Accident | 2.17 | 2.43 | 2.35 | 1.12 |
| Total Injuries (Nonfatal) | 20 | 72 | 92 | 3.60 |
| Average Injuries per Accident | 0.38 | 0.80 | 0.64 | 2.11 |

TABLE III

FISCAL YEAR 1967 DATA

ALL ACCIDENT TYPES

ROTARY WING AIRCRAFT ONLY

| ACCIDENT INDEX | U.S. ACCIDENTS | VIET NAM ACCIDENTS | ALL ACCIDENTS | VN to US RATIO |
|---|---|---|---|---|
| Major Accidents | 157 | 445 | 602 | 2.83 |
| Minor Accidents | 18 | 39 | 57 | 2.17 |
| Total Accidents | 175 | 484 | 659 | 2.77 |
| Aircraft Inventory - Per Cent Total | 40.94 | 26.93 | 67.86 | 0.66 |
| Total Flying Hours | 1,485,213 | 1,323,284 | 2,808,497 | 0.89 |
| Total Landings | 6,247,569 | 3,970,664 | 10,218,233 | 0.64 |
| Major Accidents per 100,000 Hours | 10.57 | 33.63 | 21.43 | 3.18 |
| Minor Accidents per 100,000 Hours | 1.21 | 2.95 | 2.03 | 2.44 |
| Total Accidents per 100,000 Hours | 11.78 | 36.58 | 23.46 | 3.11 |
| Major Accidents per 100,000 Landings | 2.51 | 11.21 | 5.89 | 4.47 |
| Minor Accidents per 100,000 Landings | 0.29 | 0.98 | 0.56 | 3.38 |
| Total Accidents per 100,000 Landings | 2.80 | 12.19 | 6.45 | 4.35 |
| Total Dollar Cost | 12,061,590 | 69,528,454 | 81,590,044 | 5.76 |
| Average Dollar Cost per Accident | 68,923 | 143,654 | 123,809 | 2.08 |
| Total Fatalities | 55 | 260 | 315 | 4.73 |
| Average Fatalities per Accident | 0.31 | 0.54 | 0.48 | 1.74 |
| Fatal Accidents - Number | 21 | 83 | 104 | 3.95 |
| Fatal Accidents - Percent | 12.00 | 17.15 | 15.78 | 1.43 |
| Average Fatalities per Fatal Accident | 2.62 | 3.13 | 3.03 | 1.19 |
| Total Injuries (Nonfatal) | 104 | 557 | 661 | 5.36 |
| Average Injuries per Accident | 0.59 | 1.15 | 1.00 | 1.95 |

TABLE IV

FISCAL YEAR 1967 DATA

ALL ACCIDENT TYPES

RATIO OF RW TO FW DATA

| ACCIDENT INDEX | U.S. ACCIDENTS | VIET NAM ACCIDENTS | ALL ACCIDENTS |
|---|---|---|---|
| Major Accidents | 3.27 | 5.17 | 4.49 |
| Minor Accidents | 3.60 | 9.75 | 6.33 |
| Total Accidents | 3.30 | 5.38 | 4.61 |
| Aircraft Inventory - Per Cent Total | 1.59 | 4.22 | 2.11 |
| Total Flying Hours | 3.24 | 3.70 | 3.44 |
| Total Landings | 7.53 | 11.42 | 8.67 |
| Major Accidents per 100,000 Hours | 1.01 | 1.40 | 1.31 |
| Minor Accidents per 100,000 Hours | 1.11 | 2.63 | 1.85 |
| Total Accidents per 100,000 Hours | 1.02 | 1.45 | 1.34 |
| Major Accidents per 100,000 Landings | 0.43 | 0.45 | 0.52 |
| Minor Accidents per 100,000 Landings | 0.48 | 0.85 | 0.74 |
| Total Accidents per 100,000 Landings | 0.44 | 0.47 | 0.53 |
| Total Dollar Cost | 5.27 | 5.86 | 5.77 |
| Average Dollar Cost per Accident | 1.60 | 1.09 | 1.25 |
| Total Fatalities | 4.23 | 7.65 | 6.70 |
| Average Fatalities per Accident | 1.24 | 1.42 | 1.45 |
| Fatal Accidents - Number | 3.50 | 5.93 | 5.20 |
| Fatal Accidents - Percent | 1.06 | 1.10 | 1.13 |
| Average Fatalities per Fatal Accident | 1.21 | 1.29 | 1.29 |
| Total Injuries (Nonfatal) | 5.20 | 7.74 | 7.18 |
| Average Injuries per Accident | 1.55 | 1.44 | 1.56 |

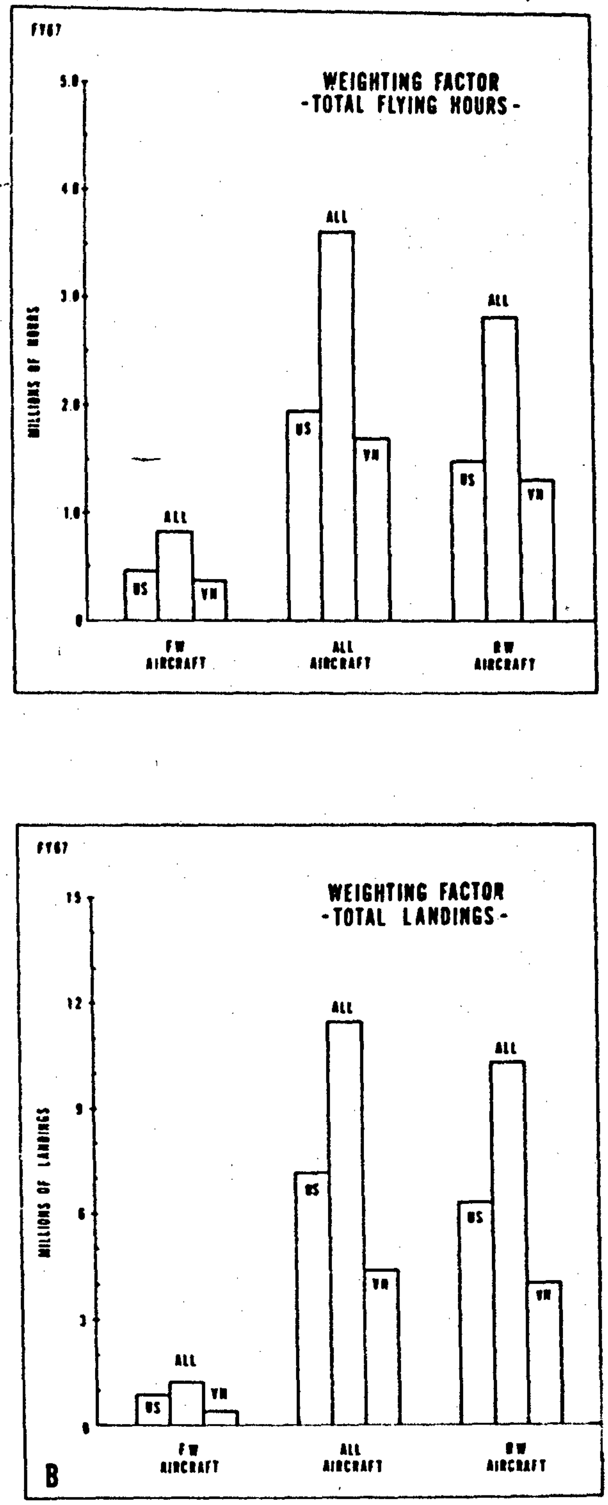



Figure 1

Total flying hours (A) and total landings (B) by aircraft type and location during fiscal year 1967. In A, the three bars at the left pertain to fixed wing (FW) aircraft with the VN bar indicating total FW hours flown in Viet Nam; the US bar total hours flown elsewhere (primarily in the United States); and the ALL bar the sum of the adjacent VN/US data. The layout of the three bars at the extreme right is identical, but pertains to RW aircraft hours. The three central bars summarize the FW and RW data and represent total hours of all aircraft types. Note that aircraft utilization in terms of hours and landings was greatest in US.

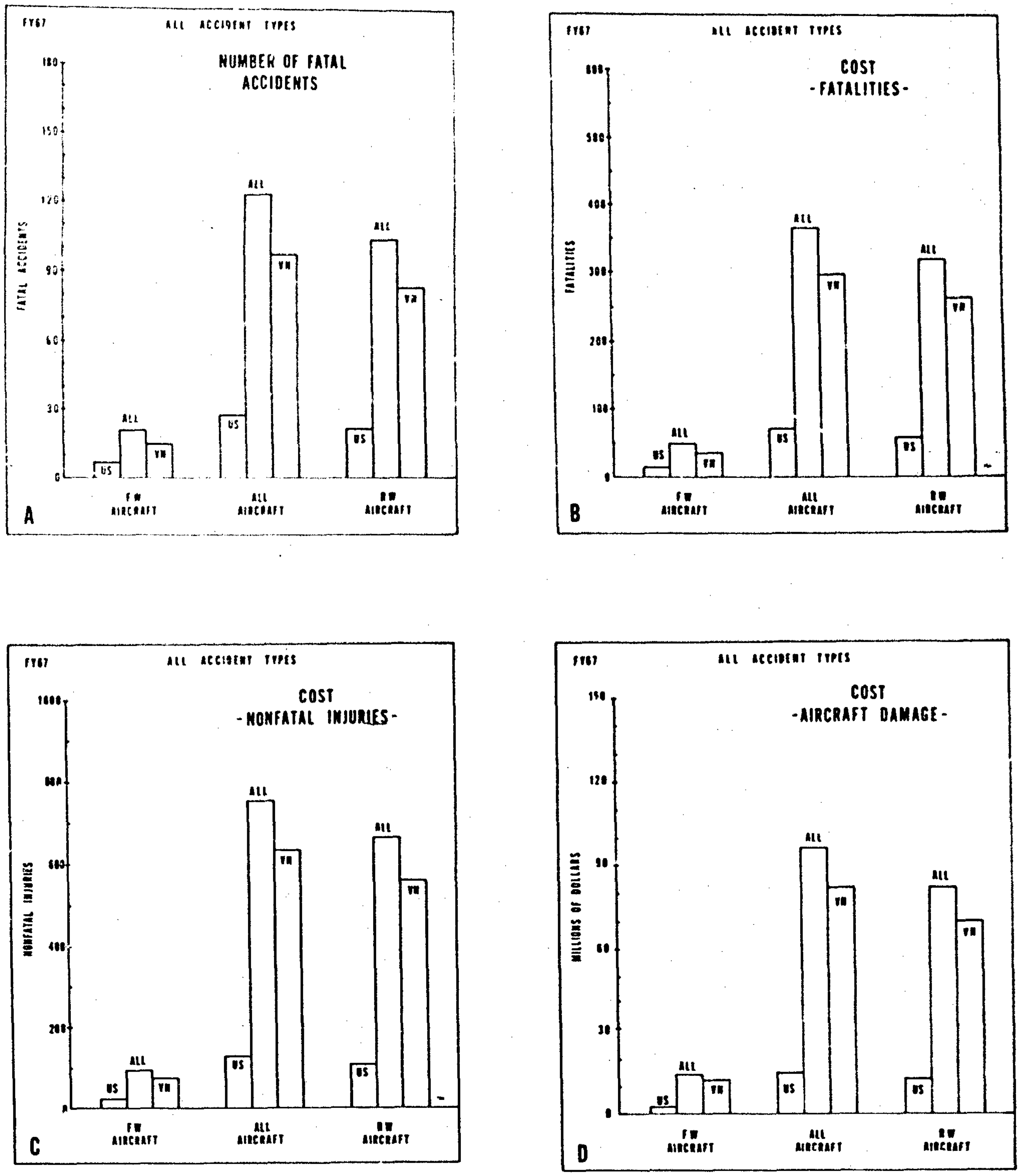
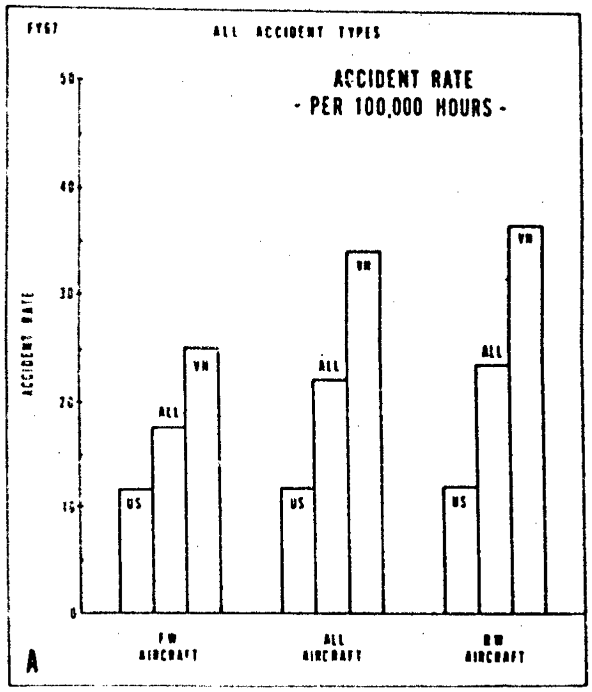



Figure 3

All Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of non-fatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both RW and FW aircraft and for both VN and US locations.



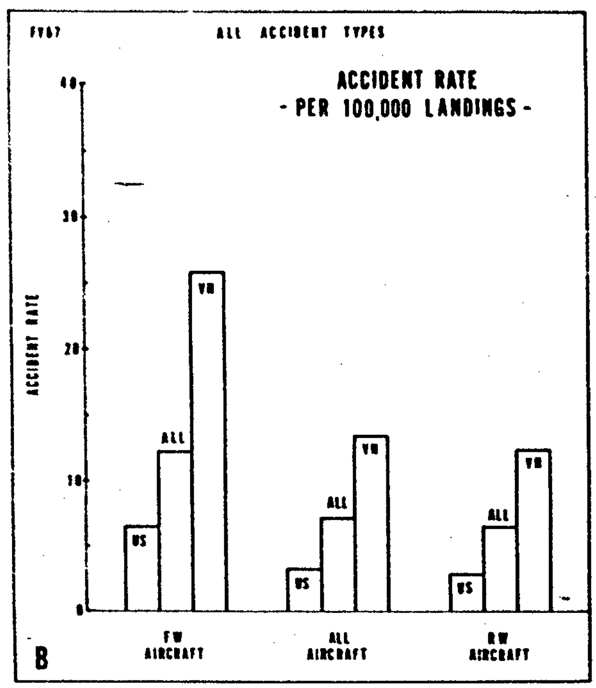




Figure 4

All Accident Types: Normalized incidence data showing average number of accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). In all cases the VN accident rate exceeded the US rate. With total hours as reference (A), the RW accident rate was greater than that of FW aircraft. When total landings were used (B), the RW accident rate fell as would be expected from the short-range, multi-hop missions typically performed by helicopters.

respectively. The pertinent incidence and cost data are outlined in Figures 10 and 11. Normalized accident rate data for these accidents are presented in Figure 12 for comparison of incidence in subsequent fiscal years.

These data show that there were a total of 57 major and minor orientation-error accidents (19 of which were fatal), resulting in 45 fatalities, 105 nonfatal injuries, and an aircraft damage cost of $10,144,034. The FW contribution was extremely small with only one minor accident and one major fatal accident occurring; the over-all cost here was one fatality, one nonfatal injury, and a total dollar damage of $27,187. It is obvious that with such a low incidence (n) for fiscal year 1967 FW orientation-error accidents, conclusions to be drawn as to RW/FW or US/VN accident incidence and cost must await the acquisition of further FW data in this longitudinal study. We have attempted to alert the reader to this low incidence in the various related graphs by listing the small n value next to the FW data. For RW aircraft, there were a total of 55 major and minor orientation-error accidents (18 of which were fatal), resulting in 44 fatalities, 104 nonfatal injuries, and a total aircraft dollar damage of $10,116,847. Thus the majority of the orientation-error accidents involving Regular Army aircraft occurred in RW aircraft in this fiscal year. As indicated by the RW data, the incidence and cost of accidents occurring in VN were both considerably greater than for accidents occurring elsewhere. This is particularly noticeable in the 17.00 to 1 VN/US fatal accident ratio, the 13.67 to 1 VN/US total fatality ratio, the 7.00 to 1 VN/US total injury ratio, and the 6.44 to 1 VN/US total dollar cost ratio.

For general reference, a breakdown of the 50 major and 7 minor orientation-error accidents by aircraft types is as follows. The FW accidents included one minor accident in an O1-D and one major accident in an O1-E. Bad weather during a night landing was involved in the O1-D accident. The O1-E accident involved a daytime flight in good visibility when a loss of depth perception resulted during a diving, low-level gunnery run over water. The UH-1 aircraft accounted for 44 of the 49 major RW accidents and 6 of the minor accidents. The remainder of the major RW accidents were accounted for by two type CH-47A aircraft, one type CH-21 aircraft, one type OH-13S aircraft, and one type TH-55 aircraft. Of these five accidents, all resulted in aircraft strikes except for the TH-55 accident. One CH-47A accident occurred at night when the aircraft flew into a low-level cloud bank during a 180-degree left turn while making a landing go-around. The second CH-47A accident involved a medical evacuation mission requiring a night takeoff into IFR weather, with spatial orientation difficulties arising when aircraft search lights reflected on low cloud cover. The CH-21 accident occurred during an IFR takeoff through thick ground smoke. In the case of the OH-13S accident, ground haze and mist during a night flight through a mountain pass resulted in aircraft control problems. The TH-55A accident resulted when the pilot assumed the sloped surface of a mountain was horizontal and controlled his aircraft accordingly.

It is quite apparent that the majority of the RW accidents involved the Army workhorse, the UH-1 "Huey." The high incidence here is due only to the UH-1 being the predominant RW aircraft in the Army inventory. Because of the many advantages to be gained from a study involving only one basic aircraft type, orientation-error accidents that

TABLE IX
FISCAL YEAR 1967 DATA

ORIENTATION-ERROR ACCIDENTS ONLY — ALL AIRCRAFT

| ACCIDENT INDEX | U.S. ACCIDENTS | VIET NAM ACCIDENTS | ALL ACCIDENTS | VN to US RATIO |
|---|---|---|---|---|
| Major Accidents | 9 | 41 | 50 | 4.56 |
| Minor Accidents | 0 | 7 | 7 | --- |
| Total Accidents | 9 | 48 | 57 | 5.33 |
| Total Dollar Cost | 1,359,844 | 8,784,190 | 10,144,034 | 6.46 |
| Average Dollar Cost per Accident | 151,094 | 183,004 | 177,966 | 1.21 |
| Total Fatalities | 3 | 42 | 45 | 14.00 |
| Average Fatalities per Accident | 0.33 | 0.88 | 0.79 | 2.67 |
| Fatal Accidents - Number | 1 | 18 | 19 | 18.00 |
| Fatal Accidents - Percent | 11.11 | 37.50 | 33.33 | 3.38 |
| Average Fatalities per Fatal Accident | 3.00 | 2.33 | 2.37 | 0.78 |
| Total Injuries (Nonfatal) | 13 | 92 | 105 | 7.08 |
| Average Injuries per Accident | 1.44 | 1.92 | 1.84 | 1.33 |

TABLE X
FISCAL YEAR 1967 DATA

ORIENTATION-ERROR ACCIDENTS ONLY — FIXED WING AIRCRAFT

| ACCIDENT INDEX | U.S. ACCIDENTS | VIET NAM ACCIDENTS | ALL ACCIDENTS | VN to US RATIO |
|---|---|---|---|---|
| Major Accidents | 0 | 1 | 1 | --- |
| Minor Accidents | 0 | 1 | 1 | --- |
| Total Accidents | 0 | 2 | 2 | --- |
| Total Dollar Cost | 0 | 27,187 | 27,187 | --- |
| Average Dollar Cost per Accident | --- | 13,594 | 13,594 | --- |
| Total Fatalities | 0 | 1 | 1 | --- |
| Average Fatalities per Accident | --- | 0.50 | 0.50 | --- |
| Fatal Accidents - Number | 0 | 1 | 1 | --- |
| Fatal Accidents - Percent | --- | 50.00 | 50.00 | --- |
| Average Fatalities per Fatal Accident | --- | 1.00 | 1.00 | --- |
| Total Injuries (Nonfatal) | 0 | 1 | 1 | --- |
| Average Injuries per Accident | --- | 0.50 | 0.50 | --- |

TABLE XI
FISCAL YEAR 1967 DATA

ORIENTATION-ERROR ACCIDENTS ONLY — ROTARY WING AIRCRAFT

| ACCIDENT INDEX | U.S. ACCIDENTS | VIET NAM ACCIDENTS | ALL ACCIDENTS | VN to US RATIO |
|---|---|---|---|---|
| Major Accidents | 9 | 40 | 49 | 4.44 |
| Minor Accidents | 0 | 6 | 6 | --- |
| Total Accidents | 9 | 46 | 55 | 5.11 |
| Total Dollar Cost | 1,359,844 | 8,757,003 | 10,116,847 | 6.44 |
| Average Dollar Cost per Accident | 151,094 | 190,370 | 183,943 | 1.26 |
| Total Fatalities | 3 | 41 | 44 | 13.67 |
| Average Fatalities per Accident | 0.33 | 0.89 | 0.80 | 2.70 |
| Fatal Accidents - Number | 1 | 17 | 18 | 17.00 |
| Fatal Accidents - Percent | 11.11 | 36.96 | 32.73 | 3.33 |
| Average Fatalities per Fatal Accident | 3.00 | 2.41 | 2.44 | 0.80 |
| Total Injuries (Nonfatal) | 13 | 91 | 104 | 7.00 |
| Average Injuries per Accident | 1.44 | 1.98 | 1.89 | 1.38 |

TABLE XII
FISCAL YEAR 1967 DATA

ORIENTATION-ERROR ACCIDENTS ONLY — RATIO OF RW TO FW DATA

| ACCIDENT INDEX | U.S. ACCIDENTS | VIET NAM ACCIDENTS | ALL ACCIDENTS |
|---|---|---|---|
| Major Accidents | 0 | 40.00 | 49.00 |
| Minor Accidents | 0 | 6.00 | 6.00 |
| Total Accidents | 0 | 23.00 | 27.50 |
| Total Dollar Cost | 0 | 322.10 | 372.12 |
| Average Dollar Cost per Accident | --- | 14.00 | 13.53 |
| Total Fatalities | 0 | 41.00 | 44.00 |
| Average Fatalities per Accident | --- | 1.78 | 0.80 |
| Fatal Accidents - Number | 0 | 17.00 | 18.00 |
| Fatal Accidents - Percent | --- | 0.74 | 0.65 |
| Average Fatalities per Fatal Accident | --- | 2.41 | 2.44 |
| Total Injuries (Nonfatal) | 0 | 91.00 | 104.00 |
| Average Injuries per Accident | --- | 3.96 | 3.78 |

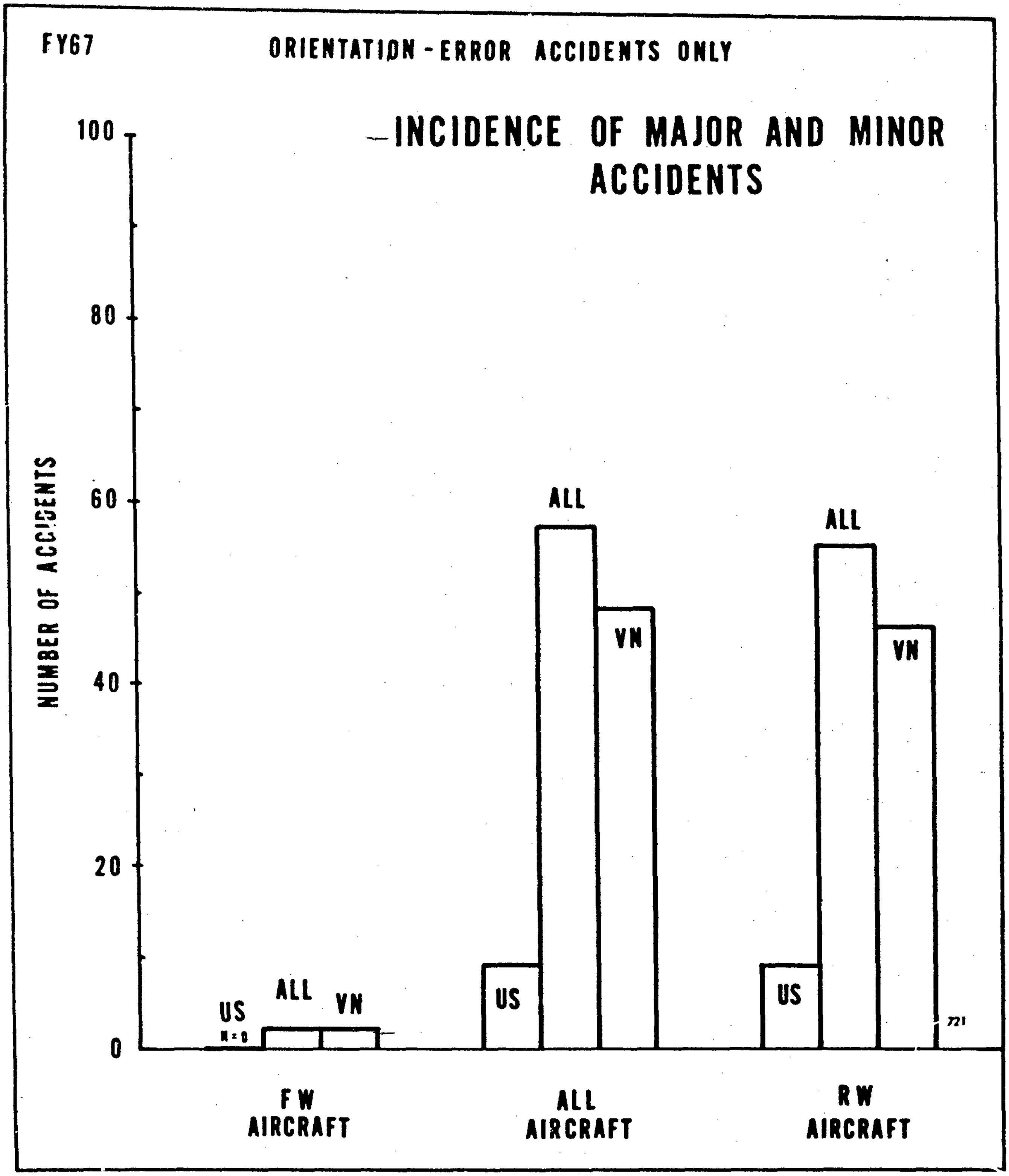



Figure 10

Orientation-Error Accident Types: Total number of major and minor orientation-error accidents located in the search of the USABAAR master accident files for fiscal year 1967. Note that only two FW accidents, both of which occurred in VN, were detected in this search.

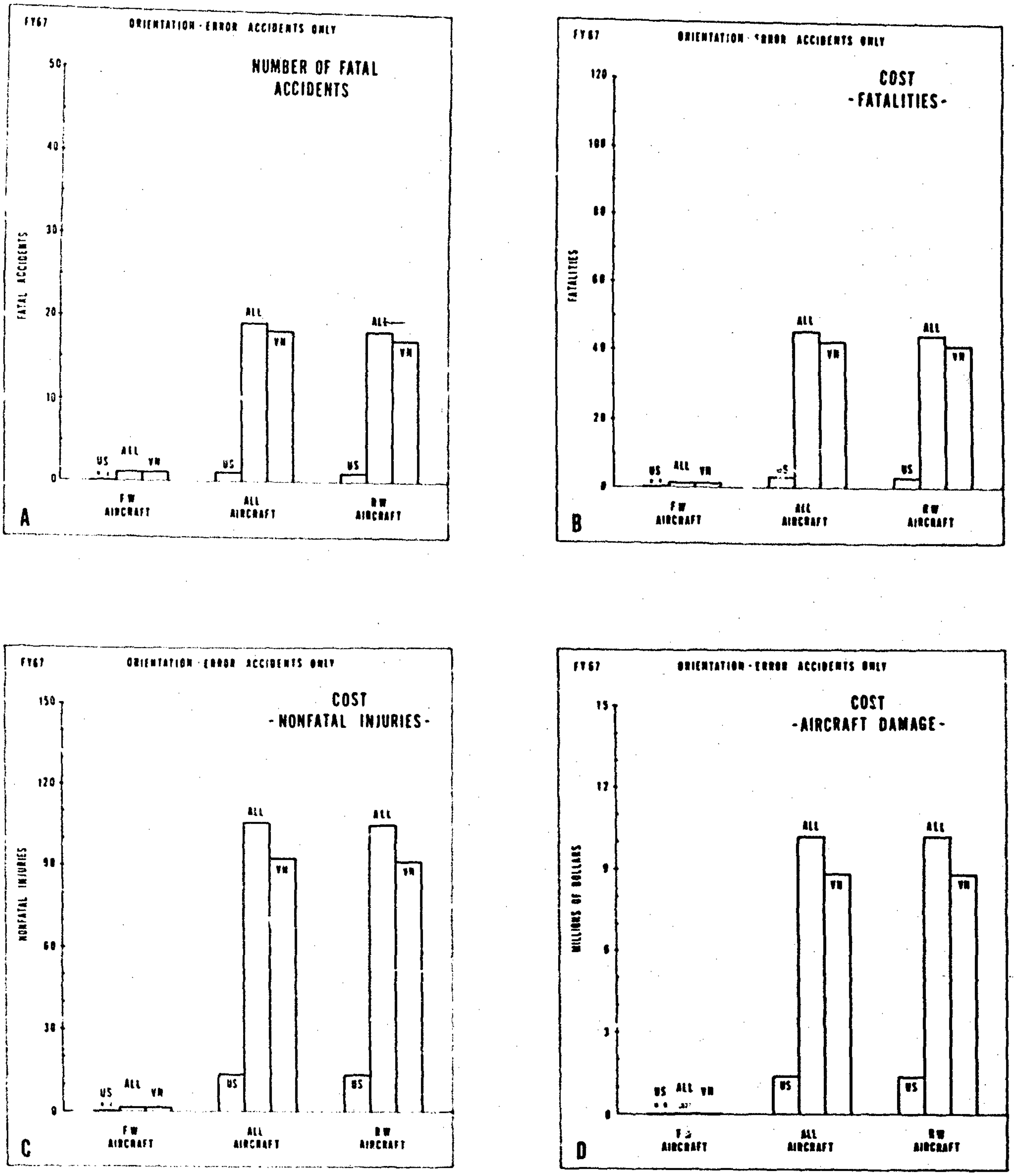
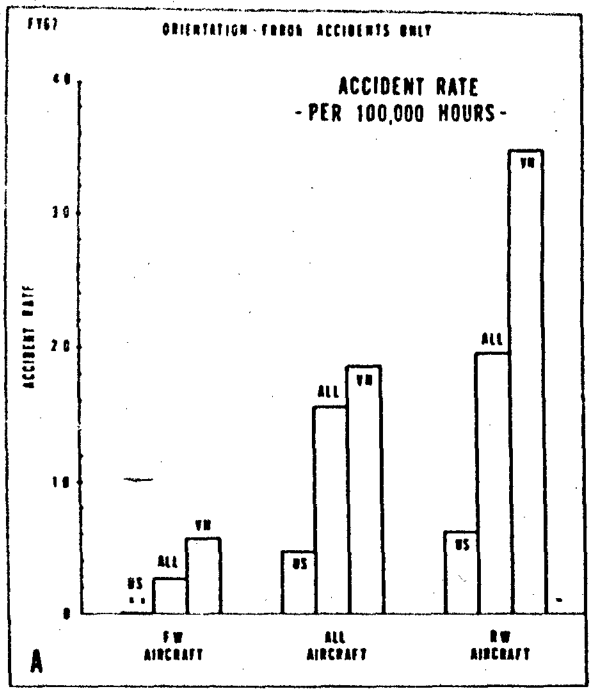



Figure 11

Orientation-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both aircraft types and for both locations. Note that there was only one fatal FW accident (A).



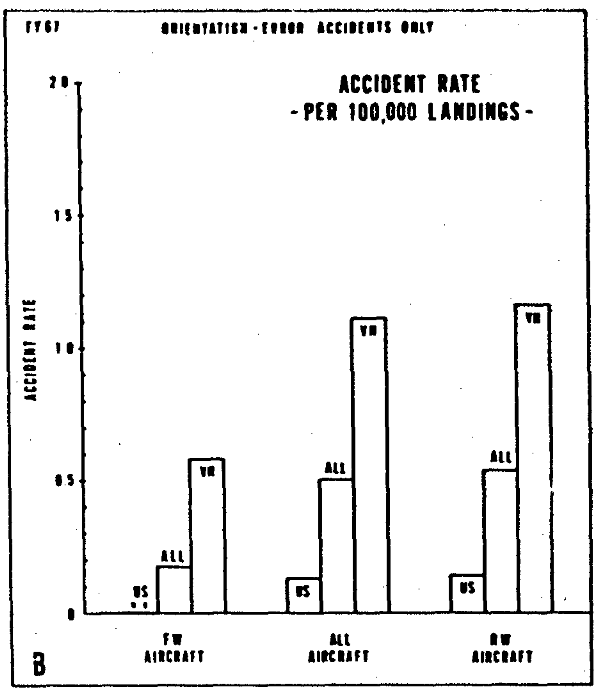




Figure 12

Orientation-Error Accident Types: Normalized incidence data showing average number of orientation-error accidents per 100,000 flying hours (A) and per 100,000 landings (B). These rate data are intended only as a fiscal year 1967 baseline reference for comparison with similar data for later fiscal years which will be presented in following reports.

occurred in the UH-1 have been selected for detailed review relative to the various pilot, aircraft, and environmental factors involved in such accidents. The results of this study for fiscal year 1967 as well as a summary of incidence and cost statistics will be described in separate UH-1 reports (5, 6).

## COMPARATIVE INCIDENCE AND COST OF ORIENTATION-ERROR ACCIDENTS

The arrangement of the data presented in the previous sections was selected to differentiate the actual incidence and cost of all accidents, pilot-error accidents, and orientation-error accidents. In this section, selected incidence and cost data are expressed in percentage figures with the objective of gaining some insight into the relative contribution of orientation-error accidents to the over-all accident problem.

In Figure 13 the percent incidence of fatal accidents is described for all accident types, pilot-error accident types, and orientation-error accident types. The Figure 13A data show that for FW aircraft 13.99 percent of all FW accidents, regardless of accident cause or type, were fatal, with the incidence in VN being about 1.37 times as great as that in US. The RW data indicate that 15.78 percent of all RW accidents were fatal, with the VN incidence 1.43 times as great as the US incidence. In effect, considering all accidents, little difference exists in FW and RW fatal accident incidence within a given location. Considering both aircraft types together, the totalized data of Figure 13A indicate 15.46 percent of all accidents were fatal.

When one evaluates only those accidents of the above group that involved pilot error, the relative incidence of fatal accidents is less, as indicated in Figure 13B. Here, the fatal accident incidence was 12.26 percent for FW aircraft, 13.68 percent for RW aircraft, and 13.59 percent for the combined sum of FW and RW pilot-error accidents. The VN/US fatal accident incidence ratio for RW aircraft was 1.95 to 1. For FW aircraft, however, the VN and US incidence ratio was about the same. A comparison of Figure 13A and 13B would indicate that during fiscal year 1967, the probability of a fatal accident occurring when pilot error was involved was slightly less than the probability of a fatal accident occurring when pilot error was not involved.

For orientation-error accidents, however, the probability of a fatal accident was much higher, as shown in Figure 13C. Again, the reader is cautioned to remember the low incidence of FW accidents for this period. The total number of FW accidents, n=2, of which one was fatal, accounts for the 50 percent fatal accident incidence data of this figure. (The FW data of Figure 13C are drawn in dashed outline to ensure recognition of this low incidence.) Thus for fiscal year 1967, the relative incidence and cost of orientation-error accidents derived almost exclusively from RW accidents. In the remaining orientation-error figures then, the "All Aircraft" data will, in essence, be identical to the "RW Aircraft" data. The percent incidence of fatal accidents when orientation error was involved rose to 33.33 percent with the incidence in VN being considerably greater than that in US; in fact, 3.38 times as great.

Similar comparisons for the three classess of accidents are made in Figure 14 for the average number of fatalities per fatal accident. Again the cost of pilot-error accident types was less than the cost of all accident types, with the VN cost exceeding the US cost. However, for orientation-error accidents the average number of fatalities per fatal accident was slightly less than that of the pilot-error accident types while the US cost, in this case, exceeded the VN cost. The same format is used in Figure 15 which depicts the average number of nonfatal injuries that occurred per accident. The all-accident type and the pilot-error accident type data were about the same. For the orientation-error accident data, however, the average number of injuries per accident was considerably higher. The higher average aircraft dollar cost of orientation-error accidents also exceeded the average cost of the other accident types, as illustrated in Figure 16.

Figures 17 through 20 illustrate the relative contribution of orientation-error accidents in all aircraft types to selected incidence and cost data as a given percentage of corresponding statistics for both "all accident types" and "pilot-error accident types." In Figure 17, orientation-error accidents can be seen to represent 7.11 percent of all accidents that occurred during this year and 10.33 percent of all pilot-error accidents. When one considers the number of fatal accidents that occurred in the two accident groups, as is done in Figure 18, orientation-error fatal accidents represent 15.32 percent of all fatal accidents and 25.33 percent of all fatal pilot-error accidents. In terms of fatalities, orientation-error accidents resulted in 12.43 percent of the total number and 23.81 percent of those occurring in pilot-error accidents, as indicated in Figure 19. Lastly, orientation-error accidents accounted for over 10.59 percent of the total cost of all accidents and 16.80 percent of the cost of all pilot-error accidents, as shown in Figure 20. The percentage contribution of orientation-error accidents to the "all accident" cost was about the same for VN as elsewhere. However, for all other data presented in Figures 17 through 20, the magnitude of the orientation-error problem in VN was considerably greater than the magnitude of the problem elsewhere.

At this time, no attempt will be made to discuss further these findings or to draw any conclusions as to their over-all significance. Since corresponding data are under preparation for subsequent fiscal years, the full significance of the fiscal year 1967 data will depend upon whether this longitudinal analysis does or does not establish the presence of consistencies or trends in the accident experiences. Moreover, it is the function of this element of the longitudinal study only to provide quantitative data; the actual evaluation of the accident data in terms of effect on the military mission must remain with those responsible for the direction of military aviation operations.

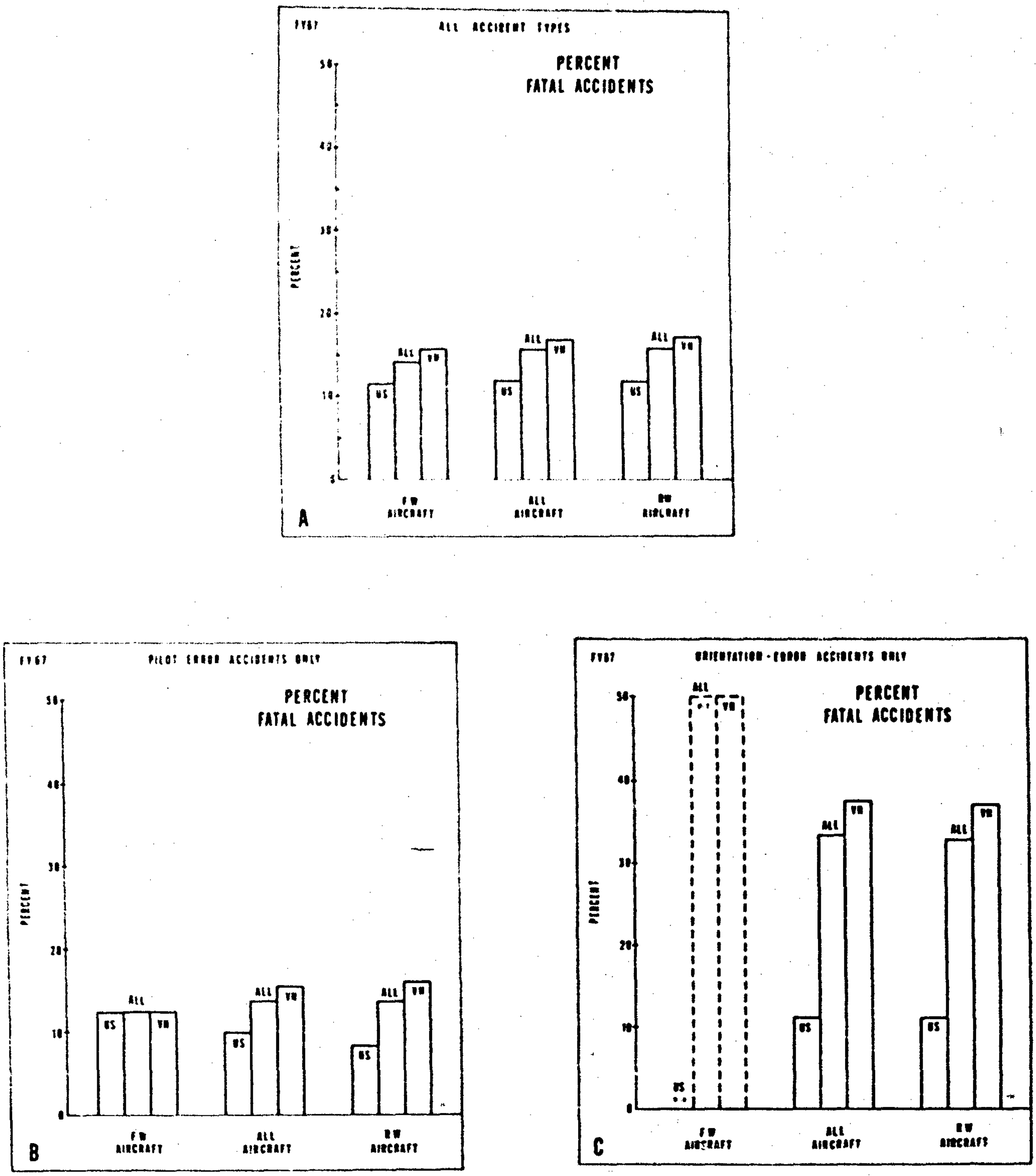



Figure 13

Comparative incidence of fatal accidents expressed as the percent of the total number of accidents within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications that resulted in one or more fatalities. Comparison of the totalized RW and FW data of (A) with their (B) counterpart, indicates that the probability of a fatal accident occurring when pilot-error was involved was slightly less than when pilot-error was not present. Note that orientation-error accidents, a specific subgroup of pilot-error accidents, had a significantly higher percentage of fatal accidents. In (C) the FW data is drawn in dashed outline to caution the reader of the very few cases involved; i.e., two FW accidents with one being fatal.

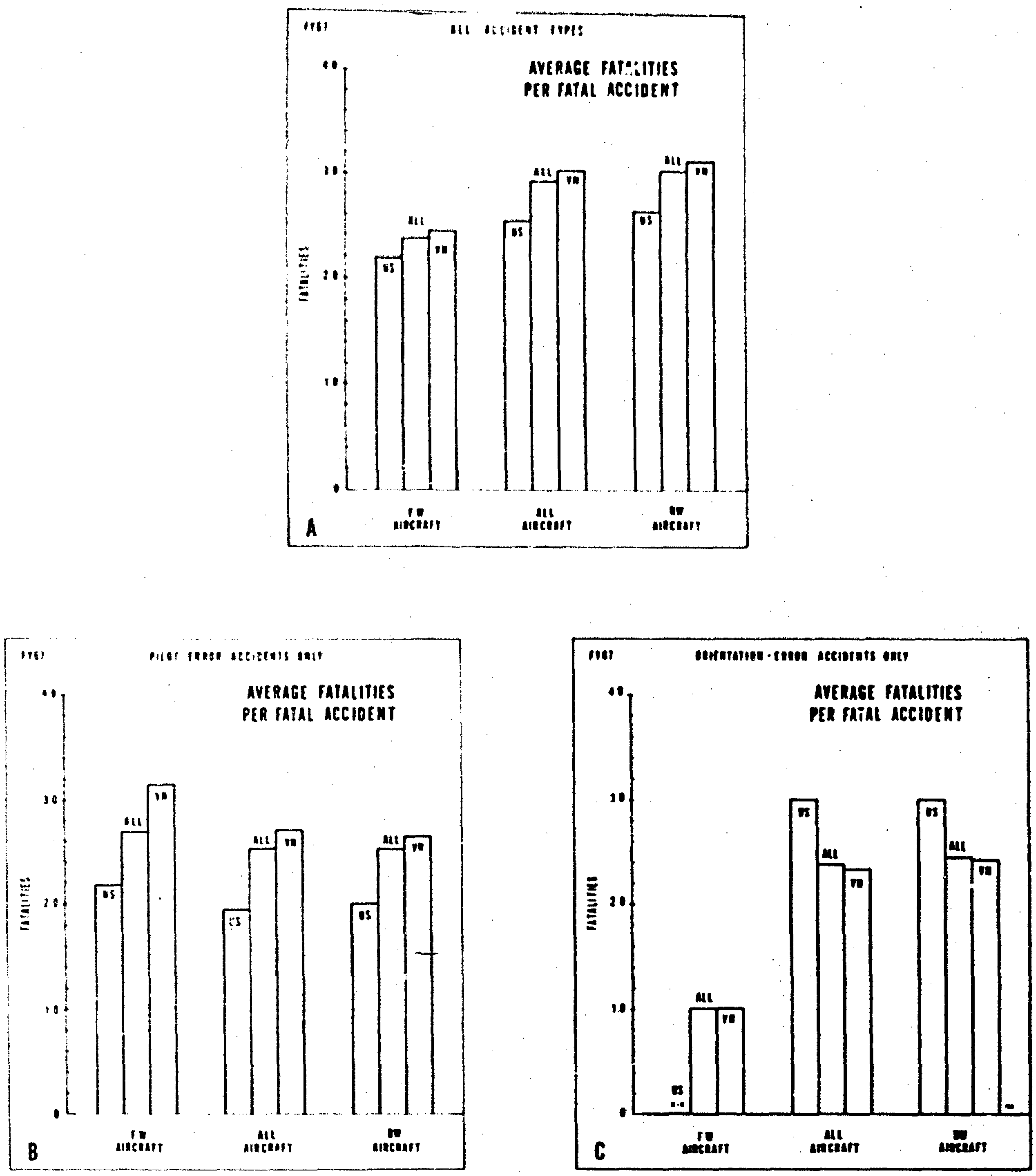



Figure 14

Average number of fatalities per fatal accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications. Because of the low number of FW accidents within the orientation-error accident classification, the "All Aircraft" data of (C) are nearly identical to the adjacent "RW Aircraft" data.

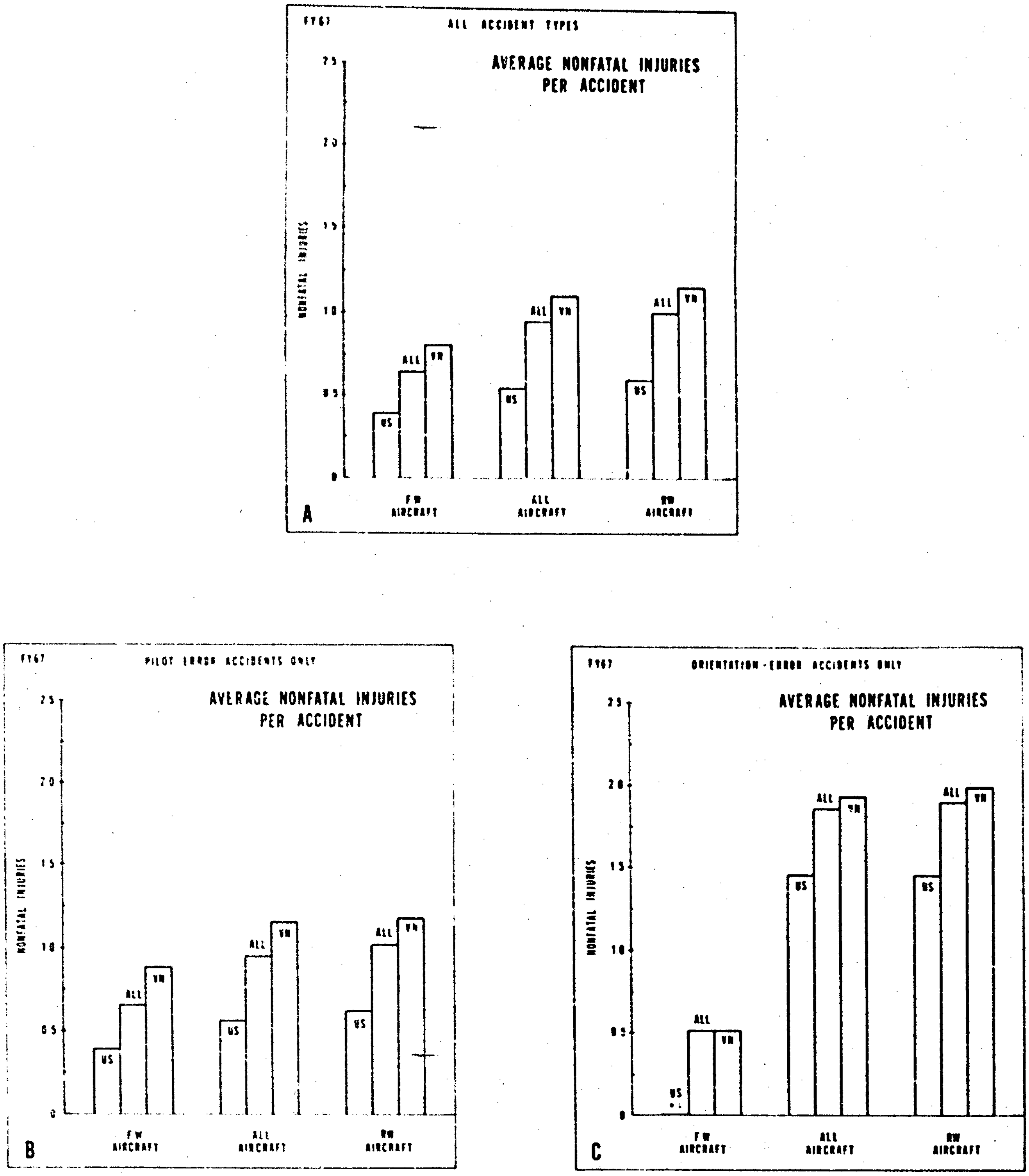



Figure 15

Average number of nonfatal injuries per accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications. The orientation-error accidents had the greatest injury rate.

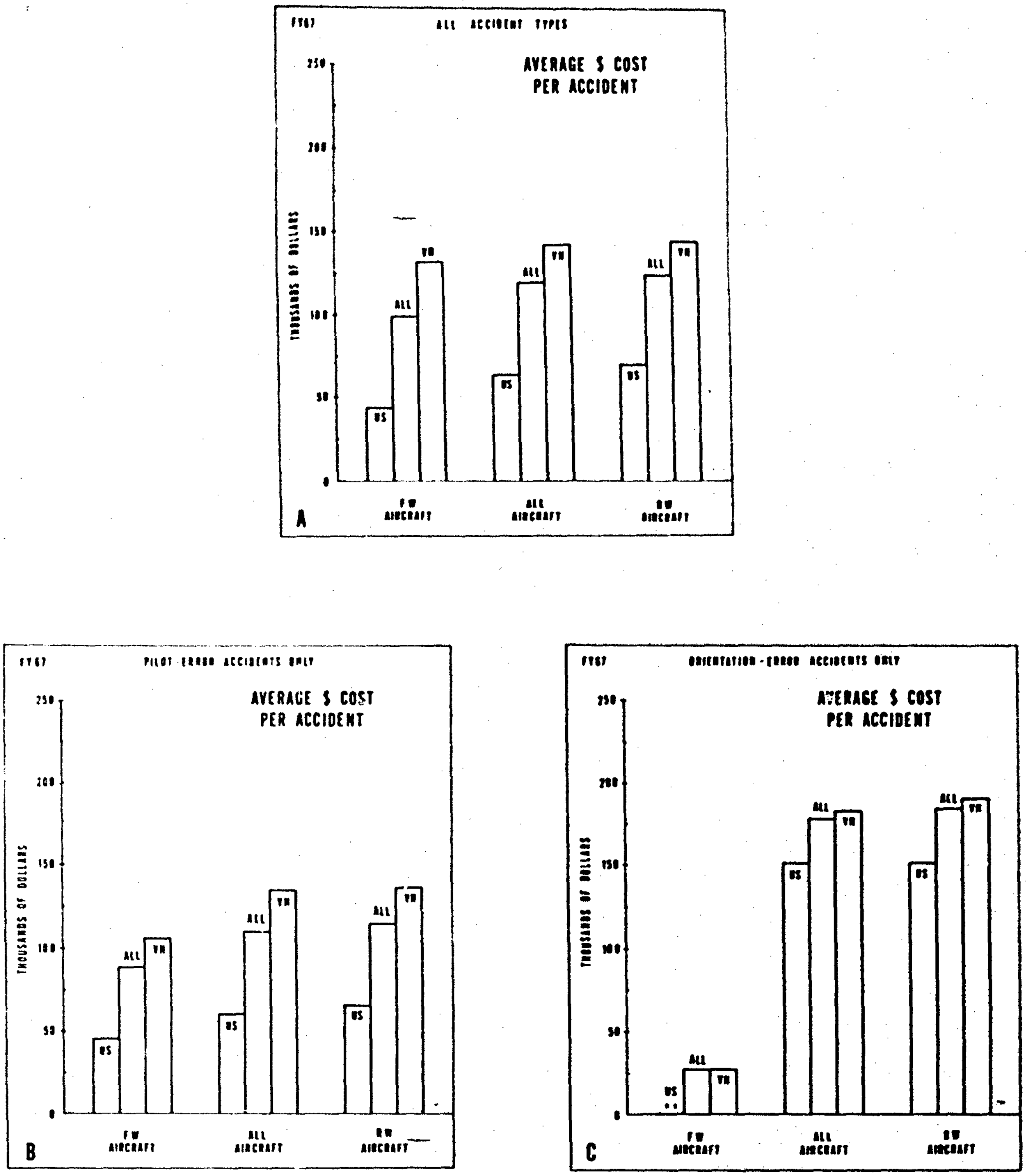



Figure 16

Average aircraft dollar damage per accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications. Orientation-error accidents produced the greatest dollar damage per accident.

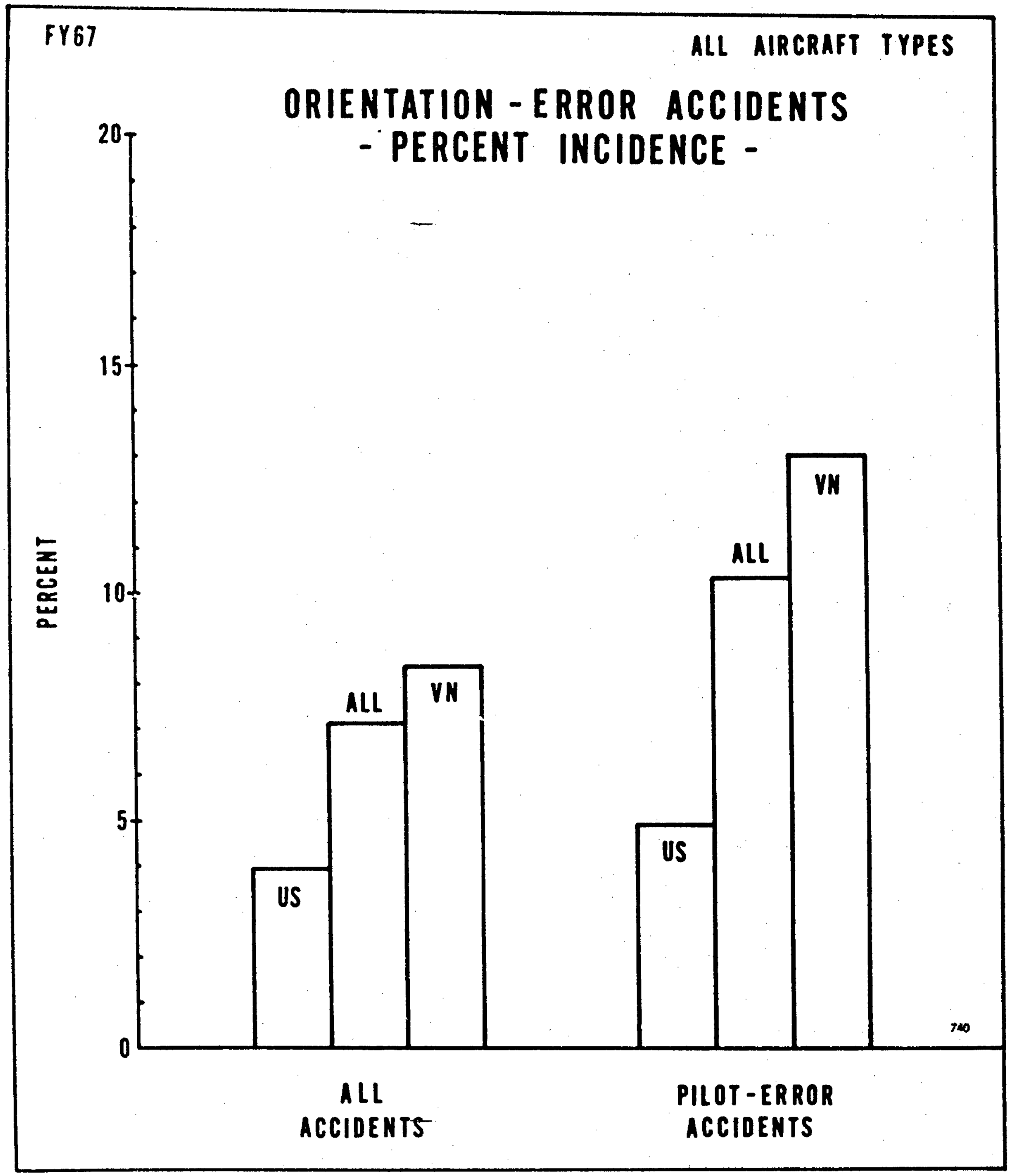



Figure 17

Percent contribution of all orientation-error accidents to the total number of accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications.

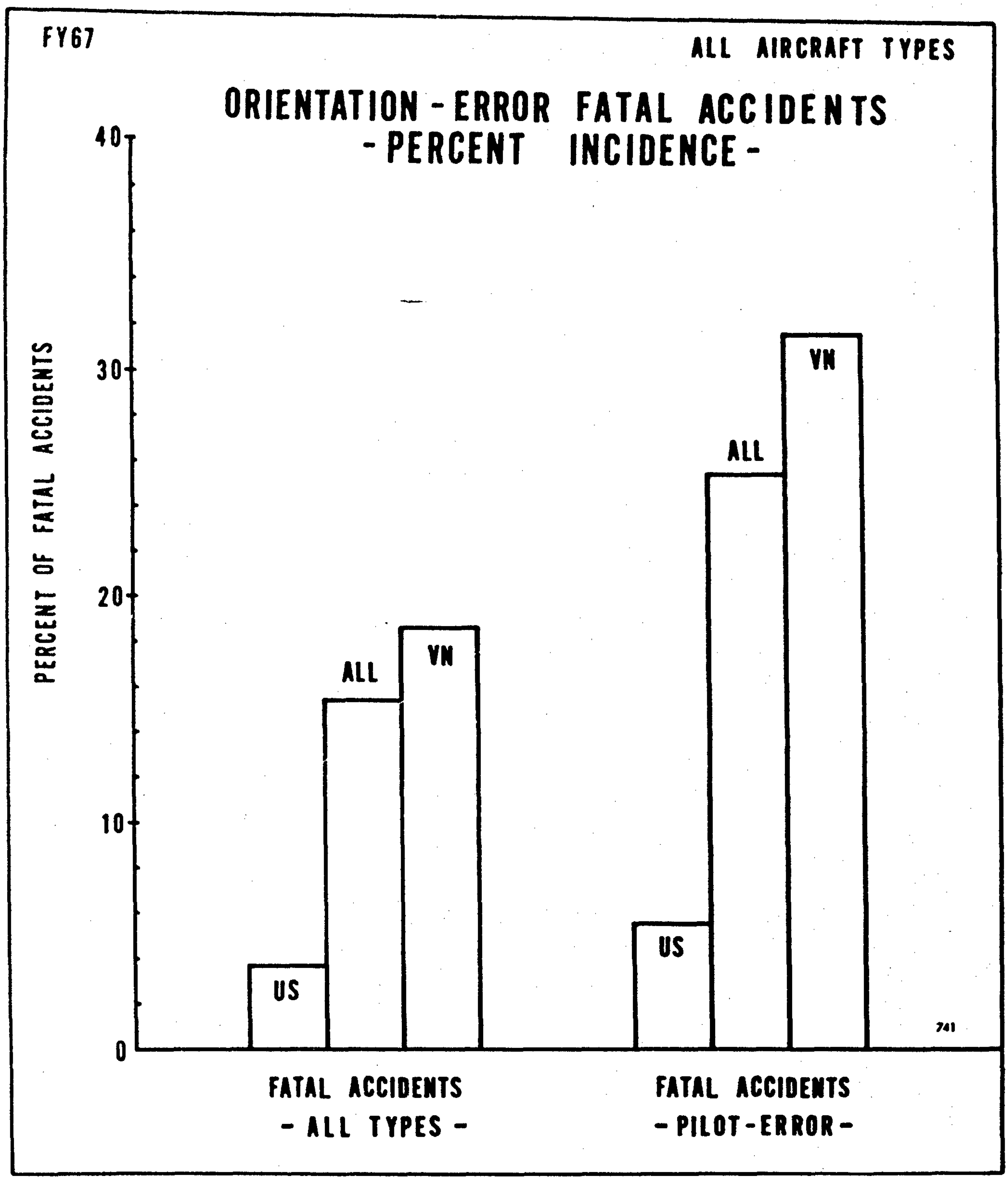



Figure 18

Percent contribution of all fatal orientation-error accidents to the total number of fatal accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Note that over 25 percent of all fatal pilot-error accidents involved orientation-error.

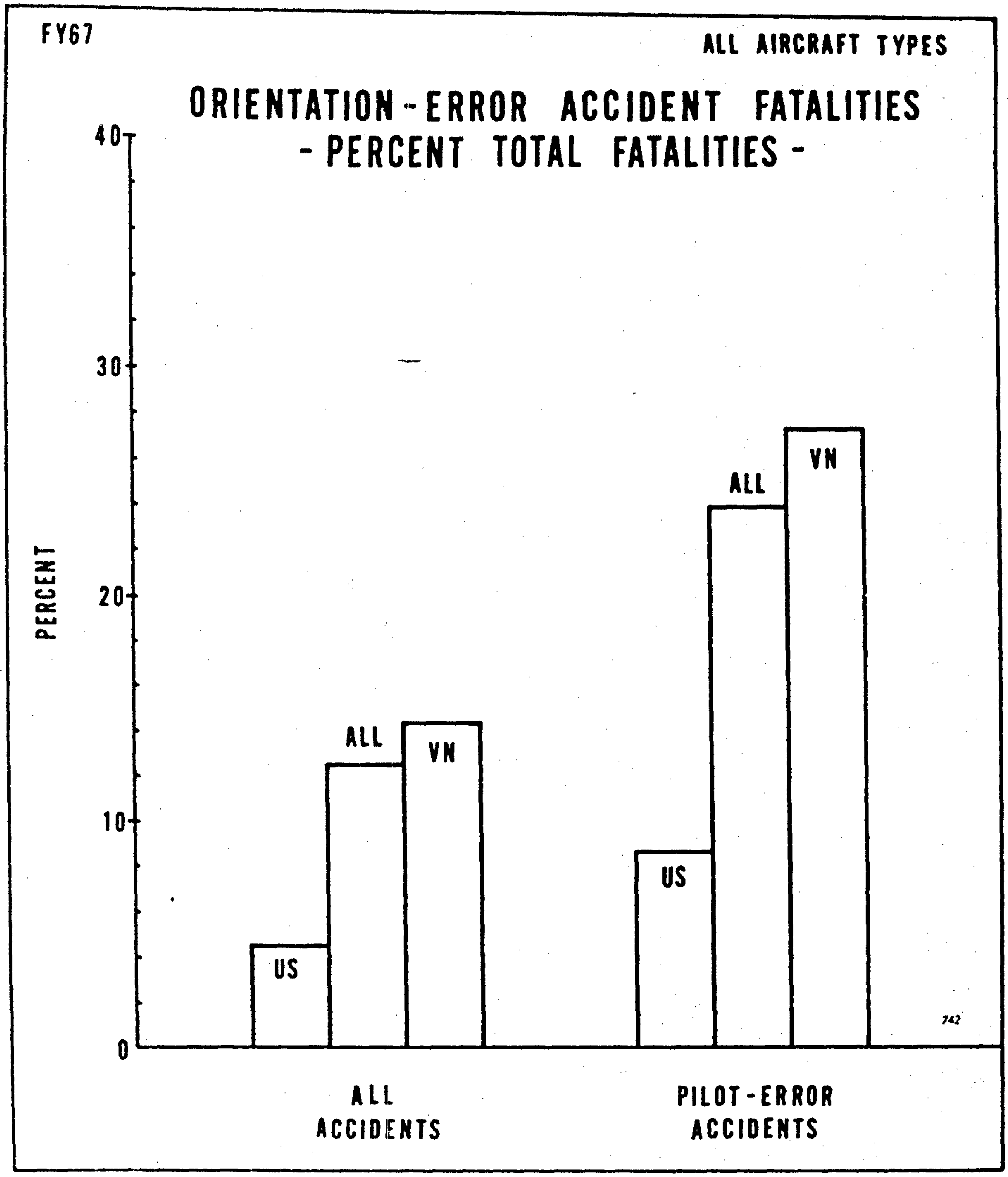



Figure 19

Percent contribution of all orientation-error accident fatalities to the total number of fatalities occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications.

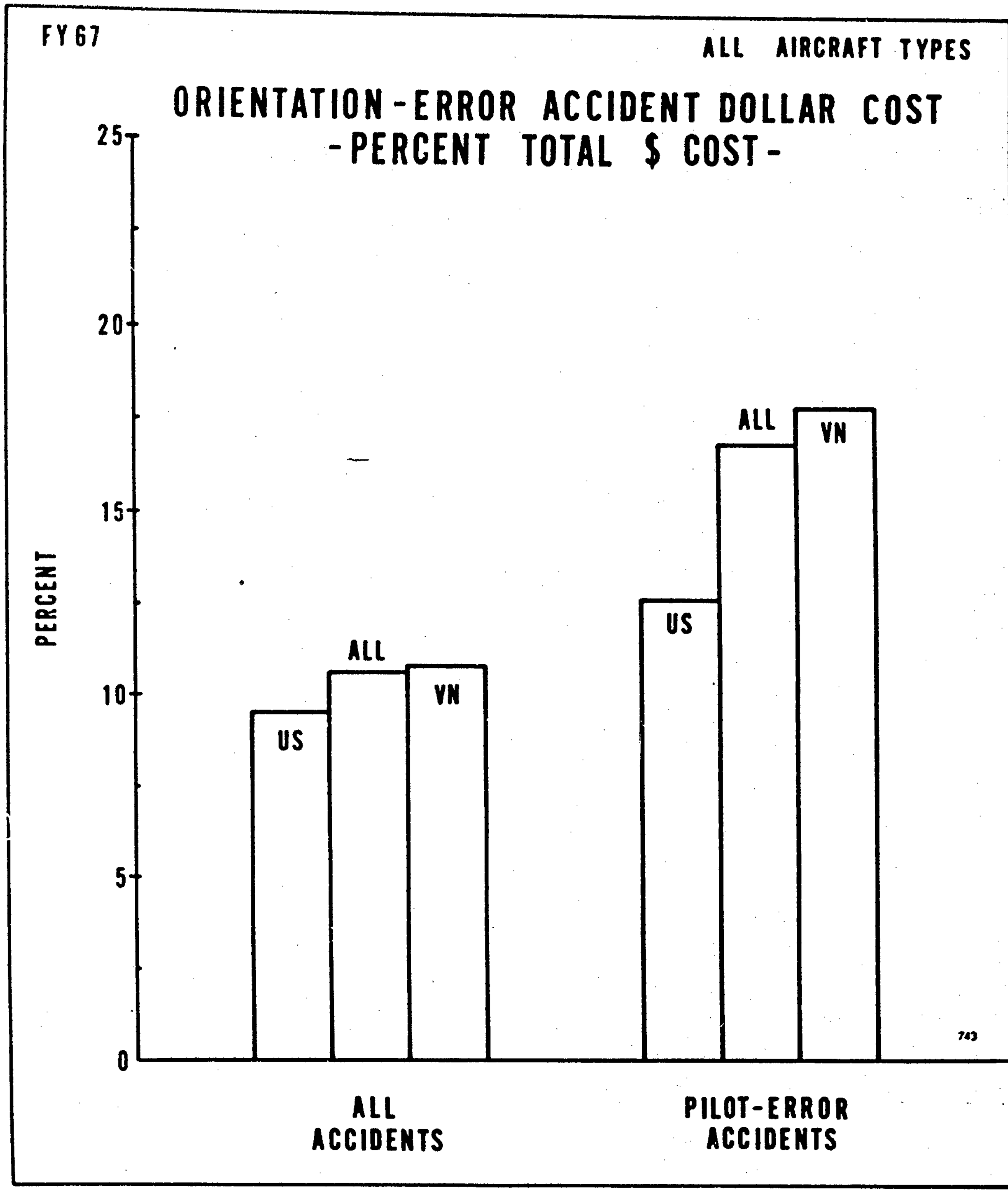



Figure 20

Percent contribution of the dollar cost of all orientation-error accidents to the total cost of all accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications.

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13. ABSTRACT

This report is the first in a longitudinal series of reports dealing with the magnitude of the pilot disorientation/vertigo accident problem in Regular Army fixed wing and rotary wing flight operations. Factors involved in the development of an operational definition of the orientation-error class of aircraft accidents are discussed. Incidence and cost data presented for fiscal year 1967 include a total of 57 major and minor orientation-error accidents (19 of which were fatal), resulting in 45 fatalities, 105 nonfatal injuries, and a total aircraft damage cost of $10,144,034. The contribution of rotary wing orientation-error accidents to this total was 55 accidents (18 of which were fatal), resulting in 44 fatalities, 104 nonfatal injuries, and a total aircraft damage cost of $10,116,847.

| 14 KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| Army aviation | | | | | | |
| Aviation medicine | | | | | | |
| Aviation safety | | | | | | |
| Aircraft accidents | | | | | | |
| Pilot disorientation | | | | | | |
| Vertigo | | | | | | |

Hixson, W. C. 1970
J. I. Niven and E. Spezia

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This report is the first in a longitudinal series of reports dealing with the magnitude of the pilot disorientation/vertigo accident problem in Regular Army fixed wing and rotary wing flight operations. Factors involved in the development of an operational definition of the orientation-error class of aircraft accidents are discussed. Incidence and cost data presented for fiscal year 1967 include a total of 57 major and minor orientation-error accidents (19 of which were fatal), resulting in 45 fatalities, 105 nonfatal injuries, and a total aircraft damage cost of $10,144,034. The contribution of rotary wing orientation-error accidents to this total was 55 accidents (18 of which were fatal), resulting in 44 fatalities, 104 nonfatal injuries, and a total aircraft damage cost of $10,116,847.

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